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ABSTRACT

This report critically reviews major empirical studies of student demand for higher education in the United States. It focuses on one policy issue, that of equalizing the access of students of different economic means and using tuition and student aid to achieve the desired distribution of those students in colleges. The studies reviewed are assessed by five major specification issues that serve as criteria for the adequacy of the experimental controls. Eight studies were chosen because they seemed to best illustrate the specification issues. The criteria are: (1) treatment of higher education as a consumptive item or investment; (2) student selection of institution type; (3) measurement of financial aid offers; (4) identification of demand-supply relationships; and (5) variations in college choice according to other factors such as sex or family income. (MSE)

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DEMAND FOR HIGHER EDUCATION IN THE UNITED STATES: A CRITICAL REVIEW OF THE EMPIRICAL LITERATURE

PREPARED UNDER A GRANT FROM LILLY ENDOWMENT, INC.

DAVID J. WEINSCHROTT

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PREFACE

Analysis of student demand for places in institutions of higher (postsecondary) education has been a separate research field within economics for nearly a decade, and a considerable literature has developed. Many empirical studies have suffered from inadequate data and specification, which has reduced their usefulness for policy analysis. With new longitudinal surveys of students now becoming available, more complete analyses can be undertaken. To facilitate the use of the new data resources, this report attempts a summary and critical review of the existing literature on the demand for higher education in the United States.

The report was prepared under a grant from the Lilly Endowment, Inc. Related Rand publications cosponsored by the Lilly Endowment are the following:

A Bayesian Model of Choice among Higher Education Institutions, by Stephen J. Carroll and Daniel A. Relles, R-2005-NIE/LE, June 1976.

The Enrollment Effects of Federal Student Aid Policies, by Stephen J. Carroll et al., R-2192-HEW/LE, June 1977.

SUMMARY

This report critically reviews major empirical studies of student demand for higher education in the United States. The research has largely been stimulated by the following policy issues:

- Equalizing the access of students of different economic means to higher education and using tuition and student aid to achieve the desired distribution of those students in colleges.
- The "crisis" of excess capacity in higher education and the opportunities for employing underused resources in the future.
- Utilizing existing higher education facilities in the face of the alternative spatial distribution of students.
- The effect of reforms in public tuition policy on the distribution of students between the public and private sectors and the financial impact on the private sector if students have freer choice.

This report focuses on the first issue.

The primary means of equalizing access to higher education are loans, outright grants, or work-study awards given to the recipient directly or through educational institutions. Such funds are assumed to increase enrollment because they lower the effective price of attendance. In the design of legislation to allocate the limited funds for loans and grants, two aspects of student response to such stimuli must be considered. First, for efficient allocation, the amounts granted two students must (1) vary directly with the relative policy significance of inducing each student to enroll, and (2) vary inversely with the student's relative price-responsiveness. For example, if it is desired to equalize representation of all income

groups, the grant to a person in one group should be larger to the extent that the members of that group are poorly represented in the overall income distribution of enrolled students; but the grant should be smaller to the extent that the members of that group show a larger price-responsiveness than the members of other groups. Second, the total amount of funding must be set so as to generate the desired number of new enrollees in all income classes. Or, if the total amount is fixed, it is desirable to specify how many new enrollees the funds are expected to bring in.

Therefore, in designing policies for subsidizing higher education, policymakers need to know both relative and absolute levels of the price-responsiveness of students in different income groups. The studies reviewed in this report all address that topic.

Confidence cannot be placed in the results of an empirical study unless the theoretical and empirical specification of the problem provides adequate controls on the experiment so that the estimated parameters reflect true responses. The studies reviewed here are assessed by five major specification issues that serve as criteria for the adequacy of the experimental controls. Eight studies were chosen because they seemed to best illustrate the specification issues. The paragraphs below list the criteria and summarize the evaluations.

Treatment of Higher Education as Consumption Item or Investment. The investment theory differs from the consumption theory mainly in presuming that students choose a program of higher education primarily for its expected returns (for example, intellectual and social skills,

higher future income). A study's emphasis of one over the other determines the selection of the explanatory factors to be analyzed. Most of the studies reviewed acknowledge the importance of the investment theory but fail to test it against the consumption theory in the empirical work.

Selection of the Choice Set. Students have several discrete and mutually exclusive options for higher education--for example, vocational-technical school, 2-year public college, and 4-year private university. Analyzing which one a given student will choose requires special empirical techniques and careful specification of the choice set. Most of the studies reviewed lack rigor in specifying the choice set and therefore produce biased estimates of the true choice probabilities.

Measurement of Financial Aid Offers. Policymakers need to know how changes in tuition or policies for grants, loans, and work-study programs are likely to affect enrollment. It cannot be presumed, without evidence, that different types of financial aid packages would have the same effect as an equivalent reduction in tuition. Owing mainly to a lack of adequate data, most of the studies reviewed do not treat the effect of offers of financial aid.

Identification of Demand/Supply Relationships. To avoid simultaneous equations bias when both demand and supply relationships include the same explanatory variables, it is necessary to clearly distinguish the functional form of the model of demand from that of the model of supply. Most of the studies reviewed circumvent the

identification problem by concentrating on cross-sectional data sources. However, in the face of the projected drop in enrollment, the supply side of the educational market needs to be analyzed in greater detail. The question of simultaniety must be analyzed not only with respect to tuition and financial aid but also admission policies.

Use of Stratified Estimates. Policymakers need to know how various classes of students are likely to differ in their price-responsiveness to the costs of higher education. The evidence to date suggests that response rates do vary between the sexes and across ability and income classes. How much they vary needs to be estimated in greater detail.

ACKNOWLEDGMENTS

The subject of this report was suggested to the author by Stephen J. Carroll, whose advice on the policy context and encouragement during the preparation of the report are much appreciated. John J. McCall and S. James Press made important and useful comments on an early draft. Christine D'Arc provided insightful and sensitive editorial assistance. Harriet Richman furnished secretarial assistance.

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I. INTRODUCTION

Student demand for places in higher education has been a subject of research interest for nearly a decade, since Campbell and Siegal's seminal article in 1967. This report surveys and assesses the empirical studies on the subject. Previous reviews of such studies have generally focused on the actual demand estimates, as if the estimates themselves were the sole object of analysis. For example, Jackson and Weathersby (1975) seek to compare demand estimates from several studies. The studies were so disparate--including cross-section and time-series perspectives; aggregate and micro units of analysis; a variety of functional forms, some constraining parameters in particular ways; and wide variance in definition of independent and dependent variables--that such comparison is meaningless. In contrast, this review assesses empirical studies in the comparable aspects of policy relevance and technical correctness. Each study is evaluated by five criteria, consisting of major specification issues.

This report is organized as follows. Section II discusses the policy issues that have stimulated much of the research in the field. Section III identifies the five criteria by which several major empirical studies are evaluated. Section IV briefly describes and then evaluates each of the eight studies chosen. Section V summarizes the findings. An extensive annotated bibliography is presented.

II. THE POLICY CONTEXT

This section describes the important policy questions that have stimulated much of the research on the demand for and supply of places in postsecondary educational institutions. First it looks at the broader policy context--the issues seen by education planners and policymakers. Then the focus narrows to the issues as seen by major researchers in the field.

THE CHANGING ROLE OF HIGHER EDUCATION

Early empirical studies of the demand for higher education were prompted by a concern for equality of opportunity. Public subsidies for the cost of higher education were urged on two grounds. First, it was argued that student aid was needed to equalize individual opportunities to make a private investment. That is, since investment markets in human capital are imperfect, persons in different circumstances, not necessarily related to ability, have unequal opportunities to borrow money for their education. Second, assuming that the more education a person has the higher his income will be, it was argued that society should make social investments in disadvantaged persons in order to minimize social costs in the future. In the early 1970s a new concern emerged--what to do about the excess capacity in the educational plant accumulated during the 1950s and 1960s if the demand for higher education dropped as projected.

Recent demographic and technological analyses have suggested that the extraordinary postwar growth of higher education owes to a coincidental expansion in requirements for college-educated labor during a period

when the educable population was declining. The expansion in demand for college-educated manpower stemmed from a shift in the composition of the final output of the U.S. economy toward sectors intensive in a college-educated labor force. The shift was rapid in the postwar period because of the restrictions imposed on technological diversification during the war and the preceding Depression. The decline in educable population in the early postwar period was also the result of Depression-related low birth rates in the 1930s. The rising demand for educated manpower led to an increase in the rate of college enrollment among high school graduates in the 1950s. That rate increased dramatically during the 1960s because the higher level of educational attainment among parents led to still higher educational goals among their children.* By the 1970s, the bulge in the educable cohorts born during and immediately after the war, coupled with a continuing high rate of college enrollment, had reversed the condition to one of excess supply.

The issue at hand is whether the enrollment rate will fall, in view of the drop in the expected rate of return on an investment in college education, or whether college-age cohorts will perceive a college education more as a consumption than an investment benefit. The demand for new degree holders may fall faster than the size of the cohort if the rate of enrollment in the cohort remains high. Whether potential students perceive college benefits as a consumption item rather than an investment has important implications for the public support of higher

*For a useful discussion of these issues, see Dresch 1975b and 1975c.

education. As the major rationale for public subsidy of higher education is based on the investment returns, a reduction of these returns would warrant a reevaluation of public subsidies.

Thus, an important research issue is to investigate why potential students seek a college education. If the motivation for public subsidy is removed, the question of how to use the educational process to equalize opportunities for advancement becomes more difficult.

POLICY ISSUES AS SEEN BY MAJOR INVESTIGATORS

Excess Capacity in Higher Education (Radner and Miller 1975)

In perhaps the most ambitious study to date, Radner and Miller view the institutions of higher education as an industry that produces outputs (educated persons) while utilizing various variable and fixed factors (students, faculty, buildings, and the like) according to particular technological relationships (faculty/student ratios). The study attempts to (1) estimate the demand for places (supply of student inputs), (2) examine the characteristics of institutions that have different faculty/student ratios, and (3) estimate and project the national supply of educated persons over the next decade or so. The purpose is to shed light on policy choices with regard to (1) requirements for new Ph.D.s in institutions with various faculty/student ratios, (2) the human and financial resources that would be needed if two years of college were made compulsory, and (3) the impact on higher education of much greater efforts in compensatory elementary and secondary education. What prompted the study was the researchers' concern about the expected "crisis" of excess capacity in the higher education industry.

The latter issue has stimulated much current research on higher education. Radner and Miller's use of the word "crisis" perhaps reflects a concern for the welfare of fellow academics in the years ahead, but it also signals the need to direct underutilized resources toward improving the quality and universality of opportunities for postsecondary education. The authors suggest two ways of increasing the demand for Ph.D.s: (1) reduce class sizes in elementary and secondary schools, and (2) extend universal education through the first two years of college. They do not make it clear, however, how these measures will help the existing supply and how the growing number of new Ph.D.s in process will adapt to the two means of increasing demand.

Equalizing Access to Higher Education (Hoenack)

Stephen Hoenack began his research on the demand for higher education in California as part of his dissertation (1968a) and continued it in later policy analyses (1968b, 1969 [with P. Feldman], 1971). His purpose was to estimate the consequences of various allocations of student aid to the distribution of income classes enrolled in California's universities and colleges. He found that because price and income elasticities of demand for places vary, the optimal subsidy of different income classes would need to vary for any desired distribution of income classes enrolled. For example, if equity in enrollment across income classes is preferred over maximum enrollment as a policy goal, a uniform low-tuition policy is not efficient. It gives a larger subsidy than necessary to persons of higher income who have high income elasticities of demand for education. The public subsidy, now uniformly applied to California college students,

should instead be directed toward lower-income students, whose income elasticities are low but who are also very price-responsive.

Adapting Educational Facilities to Changing Enrollment Patterns (Carroll and Relles 1975)

Carroll and Relles' study of freshman enrollment in the state of Florida attempted to forecast the demand for places at the various campuses in the state's higher education system. The authors did not examine the structural relationships underlying students' choices, partly because the campuses have similar characteristics, partly because disaggregated student data were not available, and partly because the interests of Florida's policymakers lay elsewhere. Thus, neither equality of access nor students' responses to financial aid were considered. Instead, the focus was on providing a reliable method for forecasting the distribution of students from the various high schools to the various college campuses. A Markov approach was taken, with transition matrices displaying the proportion of students from each high school who were expected to choose each available postsecondary option. A table gave the level of expected enrollment at various college campuses, depending on the distribution of graduating seniors at the high schools. A virtue of the study is its reliance on public data that are updated annually, facilitating periodic reestimation of the forecasting model. The study also provides descriptive estimates of the probabilities in terms of a small set of explanatory variables. The model allows policy analysts to examine the alternatives for modifying a campus in response to changes in the spatial distribution of students.

Effect of Public Tuition on Public/Private College Enrollment (Barnes et al. 1972)

Assuming that uniform low tuition at public colleges deprives students of equal access to private colleges, Barnes et al. analyzed an alternative policy using data from North Carolina. They examined the consequences of charging full tuition at public colleges but returning the revenue directly to needy students rather than channeling it through institutions. The objective was to provide students a freer choice of public or private college and perhaps avoid the financial effect of universal low public tuition on enrollment at private institutions. Although the study suffers from several technical defects, it is a good example of the attention being given this issue.

III. EVALUATION CRITERIA

This section describes how the empirical studies reviewed in Sec. IV were chosen for evaluation and discusses in detail the five specification issues used as evaluation criteria.

Two approaches are generally taken in empirical research: analysis (producing behavioral or structural models) and prediction (producing forecasting models). A particular study may include either or both approaches.

Though the difference between the two types of models is not always clear, a gross distinction can be made. Forecasting models provide point estimates of the future values of variables, assuming that the underlying structural relationships remain stable. Behavioral models, on the other hand, often provide less accurate point estimates but permit a rough analysis of outcomes when some structural relationships are permitted to vary. The literature review in Sec. IV addresses behavioral models in order to focus on the comparable theoretical dimensions of behavioral structures, which would not be possible with the diverse approaches used in simulation or prediction models. Because of that limitation, Sec. IV does not evaluate the Carroll-Relles study mentioned in Sec. II.

Study of the literature suggested five major specification issues as appropriate criteria for evaluating the state of current research. They are problems that every investigator has had to deal with in research on higher education. The eight empirical studies chosen for review in Sec. IV were selected because they seemed to best illustrate these issues.

TREATMENT OF HIGHER EDUCATION AS CONSUMPTION ITEM OR INVESTMENT

In addressing issues in higher education, economists have brought along their toolkit of behavioral models developed for other areas of economics. The two central models of economic analysis, the theory of the firm and the theory of the consumer, have yielded two models for analyzing of the demand for higher education services.*

The first model, which follows from the theory of the firm, has been termed the investment model. It asserts that a person seeks to maximize the present value (monetary and nonmonetary) of the several alternative uses of time available to him. One of the alternatives is to enroll in a program of higher education. To pursue a college career is to incur costs as well as benefits. Benefits include the present value of the expected wealth increment accruing from professional training, and associated nonmonetary benefits, such as aesthetic enrichment and mental stimulation, occuring during and after the investment (schooling) period. Costs, on the other hand, almost all occur within the investment period. They include the direct monetary costs of expenditures for tuition and foregone earnings while occupied as a student. Nonmonetary costs include the psychic costs of long hours of study and the risk of failure.

The decision to seek or not to seek higher education depends on the relative evaluation of these costs and benefits. Under conditions of perfect capital markets, a person can borrow, at the current market interest rate, against the expected wealth increment due to this college

*Although the policy issues may differ in studies of higher education, the empirical basis is quite consistently an analysis of the demand for higher education services. Only the form of the demand analysis changes according to the policy issue.

education to finance his education. If funds to finance educational investments are not available or limited (imperfect capital markets), the costs of the investment period must be met from savings or current income. Then the market rate of interest is irrelevant, and the person uses his subjective discount rate to evaluate the future wealth increment against the current costs. Lack of access to the capital market to finance educational investments means that the quantity of individual savings and income plus any financial aid constrains the total schooling costs and living costs that can be borne during the schooling period.

In the investment model, higher educational services are treated as a derived demand, an input for producing a future wealth increment. In the consumption model, educational services are valued for their own sake. It is possible for educational services to enter a model in both senses. Dominance of either the investment or consumption model has policy implications, discussed above in Sec. II. Both models imply negative own price effects, positive cross-price effects, and positive wealth effects.

SELECTION OF THE CHOICE SET

The question of selecting of the relevant choice set derives from the nature of the problem of choice. Since the choice of a college to attend is a discrete choice, changes in observed aggregate demand reflect only entry or exit from the market and not movements along individual demand curves. When an increase in aggregate demand occurs because of, say, a change in admission requirements or a reduction in the cost of attending college, then the set of individuals in the market has

increased. The estimation problem is to determine the distribution of decision rules in the population of college attenders in order to measure the amount of entry or exit for given changes in relevant policy variables. This notion of entry and exit from a "market" applies to both the college-going decision and the college-choice decision.* McFadden has expressed the theoretical model of choice as follows:**

$$P(X_k|S,B) = P[\{h \in H | h(S,B) = X_k\}], \qquad (1)$$

where X_k = the attribute vector of the chosen alternative,

S = the attribute vector of the decisionmaker,

B = the subset of alternatives confronting the decisionmaker,

h = the decisionmaker's rule that maps (S, B) into x,

H = the set of rules of all decisionmakers in the population, and

$\in$ = the operator denoting membership.

Equation 1 states that the conditional probability of observing outcome X_k, given attribute vector S and choice set B, is equivalent to observing decision rule h (a member of H) when h (S, B) is the decision rule that yields X_k for attribute vector S and choice set B.

The purpose of the model, as indicated above, is to determine the parameters of the distribution of h in H. It is important to note that the estimated probabilities usually depend on the set of alternatives included in the model. If that set does not correspond

*The distinction between college-going and college-choice decisions is a traditional one in research on higher education, but it is not necessary and may lead to misspecification of empirical models. This is explained below.

**McFadden 1974, p. 107.

to the actual set facing the decisionmaker, the resulting model will be misspecified. Many investigators have chosen the logistic function as the basis for the empirical formulation of Eq. (1). For the m-way or general polytomous choice situation, the functional form is the following:

$$P(X_k|S_i\ B) = \exp[C'Z_k] / \sum_{i \in B} [\exp\ C'Z_i], \qquad (2)$$

where $Z_i = (S_i, B)$ is a partitioned vector containing S_i, B, and C is a vector of unknown coefficients to be estimated. The explanatory variables in B and S_i consist of the attributes of the available choices and the attributes of the ith decisionmaker.

The choice set must be correctly represented in the specification in two ways. First, the list of X's must be sufficient to describe the factors that influence the decisionmaker's rule, h(X,s). Second, the choice set B must include all of the relevant alternatives confronting the decisionmaker. This implies that unless a very restrictive condition holds, polytomous estimating techniques are required to avoid misspecification.

The restrictive assumption, which is required in order to avoid specifying all the alternatives, is the so-called assumption of "independence of (from) irrelevant alternatives." The odds of a choice of option y over x in a multiple-choice situation are assumed to equal the odds of a binary choice of y over x. An implication is that multi-choice decisions can be modeled as a series of binary choices. Further assumptions are required to implement a sequential model. In

particular, the analyst must order the sequence so that decisions made in an earlier stage can be taken a data to a later stage and that decisions made in later stages are irrelevant to decisions made in earlier stages. A second assumption is that a decision made in an earlier stage does not constrain decisions made in later stages; that is, a choice against an option at an earlier stage does not preclude its availability at a later stage. An example of failure in both assumptions is given in the review of the Barnes et al. study (1975), Sec. IV.

Because of the restrictiveness of the assumptions required, it is usually not possible in decisions regarding college choice to represent the choice set as a sequential choice problem. The empirical estimation of choice behavior then becomes intractable since reasonable choice sets including all colleges that a student might consider are so large as to preclude estimation with current software. Up to now the relevant objects of choice have been individual colleges. That is, each college is considered unique so its representation in a choice set is a single point in Rn where there are n colleges to choose from. It is more reasonable, however, to assume that all colleges can be represented by a finite set of characteristics of size m where m is less than n. Viewed thus, students choose particular combinations of these characteristics instead of choosing among colleges per se.* The objects of choice are defined as particular combinations of relevant characteristics, and the explanatory variables measure how a choice among the combinations

*This approach is analogous to Lancaster's "new" approach to consumer theory (1966). For an interesting discussion of this point, see Manski (1973), pp. 13ff.

is affected by changes in student or choice attributes. The technique usually requires a polytomous choice estimator since the criticism of the sequential decision model applies here as well. Then, the key to the valid representation of a choice set is to define a correct typology of characteristics and to include the relevant explanatory variables that enter into a student's choice among the elements of the typology.

The use of a polytomous estimating technique is neither simple nor inexpensive. Two asymtotically equivalent logistic techniques are available: (1) the maximum likelihood iterative techniques of McFadden, Manski, and Nerlove and Press, and (2) Berkson's minimum logit chi-square procedure generalized to the polytomous case.*

The maximum likelihood procedures are computationally more complicated and therefore more costly than the Berkson technique. But the Berkson technique is suitable only for very large samples since it requires several replications of each representative decisionmaker. Dichotomous maximum likelihood procedures are much less expensive than their polytomous counterparts.** Use of these techniques requires the independence assumption mentioned above if a polytomous choice set is involved. Investigators who use a linear-probability function (least squares analysis of a 0-1 dependent variable) are implicitly assuming that it approximates the logistic or probit estimators. If the observed

*Polytomous maximum likelihood estimators are described in McFadden (1974), Manski (1973), and Nerlove and Press (1973). The minimum chi-square polytomous estimator is described in Cox (1970), pp. 105-107, Theil (1970), and Weinschrott (1976).

**Dichotomous maximum likelihood techniques are described in Cox (1970), and the software is described in Brelsford and Relles (1975) and Maurer and Weinschrott (1976).

range of choice probabilities approaches either 0 or 1, this technique results in biased estimates.*

Neither of the two other techniques available uses direct estimates of the logistic function. The first is multi-group discriminant analysis. It requires that the explanatory variables follow the multivariate normal distribution with equal covariance matrices in the different groups. Departures from normality will bias the results more than with the maximum likelihood approaches.** The other technique is an empirical Bayes procedure (a generalization of standard discriminant analysis) that was developed as a less expensive alternative to the maximum likelihood logistic estimator.*** Experiments with the Radner-Miller model suggest that the Bayes technique generates better predictions than the McFadden estimator.

MEASUREMENT OF FINANCIAL AID OFFERS

A troublesome problem in the analysis of college choice has been the lack of sufficient data to describe the offers of financial aid from schools not chosen by the student. Failure to include relevant cross-price information biases the estimates of all the estimated coefficients of the demand relation. In particular, if alternative offers of aid are all positively correlated, the omission of any offer will bias the remaining estimates of the financial aid effects away from zero.

IDENTIFICATION OF DEMAND/SUPPLY RELATIONSHIPS

A perennial issue is whether the estimated demand parameters are

*See Nerlove and Press (1973), pp. 3-8.
**See Halperin et al. (1971), p. 152.
***See Carroll and Relles (1976).

free from simultaneous equations bias. The issue derives from a theoretical problem in econometrics called the identification problem. Though the econometrics literature contains intuitive and rigorous mathematical descriptions of the conditions under which this problem arises, many of the studies to be reviewed are not clear on the issue. The following paragraphs set forth a concise framework for evaluating research with regard to the identification problem, to enable examination of the eight studies in common terms.

Briefly, the identification problem arises when the functional form of an empirical model of demand is not distinct from that of an empirical supply relationship. This occurs when both the demand and supply relationships include approximately the same explanatory variables. Then, as these variables change over the set of observations, both the demand and supply relationships move. Since the only data observed, say, in the price-quantity space are at the intersection of the two schedules, the succession of such points may not trace out either of the schedules if they are both moving in response to the same variables.* However, if, for example, the demand relation remains fixed and the supply curve moves, then the observed intersections of the two relationships will trace out the demand relationship.

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*The following three sources comprehensively discuss the identification problem in increasing order of sophistication: E. J. Working, "What Do Statistical Demand Curves Show?" Quarterly Journal of Economics, Vol. 41, February 1927, pp. 212-235, reprinted as Chap. 4 in G. Stigler and K. Boulding (eds.), Readings in Price Theory, Richard D. Irwin, Chicago, 1952, pp. 97-115; C. Christ, Econometric Models and Methods, John Wiley & Sons, New York, 1966, Chap. 8; and F. Fisher, The Identification Problem in Econometrics, McGraw-Hill Book Company, New York, 1966.

Several classes of models may or may not involve simultaneous equations bias if estimated by Ordinary Least Squares (OLS). We use these classes to illustrate the identification problem in research on higher education. In all cases the model includes a specification for both the demand and supply sides of the market.

Class 1: No identification

$$\text{(supply)} \quad P = A0 + A1 \cdot Q + A2 \cdot Y + E1$$

$$\text{(demand)} \quad Q = B0 + B1 \cdot P + B2 \cdot Y + E2,$$

where P,Q are jointly determined:

P = tuition

Q = enrollment

Y = family income.

As the model stands, neither the demand nor the supply relation can be statistically identified from observed information alone.

Class 2: Identification by means of recursiveness

$$\text{(supply)} \quad P = A0 + A2 \cdot Y + E1$$

$$\text{(demand)} \quad Q = B0 + B1 \cdot P + B2 \cdot Y + E2,$$

where Q is determined conditional on P.

If the coefficient A1 in the class 1 model is assumed to be 0 in the supply equation, as in the class 2 model, and E1 and E2 are not correlated, then both supply and demand equations are identified and can be estimated by OLS.

Class 3a: Identification by means of exclusion restrictions

$$\text{(supply)} \quad P = A0 + A1 \cdot Q + A2 \cdot Y + A3 \cdot Z + E1$$

$$\text{(demand)} \quad Q = B0 + B1 \cdot P + B2 \cdot Y + E2,$$

where P,Q are jointly determined and Z is an exogenous variable.

The demand equation is identified here because of the exclusion of Z, but it must be estimated by a simultaneous equations technique to avoid inconsistent estimates. The supply equation in this example is not identified.

Class 3b: Identification by incorporating predetermined tuition and a capacity constraint where demand and supply are resolved by the setting of the selection criteria

$$\text{(ability)} \quad S = A0 + A1 \cdot NUMAPP + A2 \cdot MSAT + A3 \cdot VSAT + A4 \cdot SEATS + A5 \cdot FACULTY + E1$$

$$\text{(tuition)} \quad P = B0 + B1 \cdot COST(-t) + B2 \cdot BUDGET(-t) + \ldots + E2$$

$$\text{(demand)} \quad Q = C0 + C1 \cdot S + C2 \cdot P + C3 \cdot Y + \ldots + E3,$$

where S = lowest level of aptitude accepted for admittance

NUMAPP = number of applications submitted

MSAT, VSAT = mean and variance of SAT scores on submitted applications

SEATS,
FACULTY = physical and personnel resources available for current year

COST(-t),
BUDGET(-t) = unknown lag structure of past levels of costs and budgets.

In this model, S is determined so that Q is consistent with the available physical and personnel resources, i.e., S and Q are jointly determined. Tuition (P) also affects demands, but it is predetermined.

In the literature, many analysts regard the seminal article by Campbell and Siegal as a class 1 model. Most researchers rely on models in class 2 and argue that the definition of price is independent of the demand equation but that tuition level is effective in determining the level of enrollment. No published studies have used class 3a models, which are a generalization of class 2. The model presented as class 3b shifts the focus considerably since it relegates tuition to a predetermined variable and proposes ability as the market-clearing variable. This model is only a prototype, and it is not a complete specification. It is given to indicate how a more reasonable view of institutional arrangements leads to a quite different framework than has been advanced heretofore. Corazzini et al. (1969) hint at a structure similar to the class 3b model when they acknowledge financial and aptitude barriers as major determinates of enrollment.

USE OF STRATIFIED ESTIMATES

The final criterion has to do with whether estimated parameters differ across ability/income classifications. In attempting to determine an appropriate allocation of financial aid among different ability and income groups, many empirical studies have segmented their samples into several strata. In most cases the stratification is significant in that the estimated coefficients differ across cells. This suggests that later research should also stratify the sample to avoid the aggregation bias that would result from pooling the cells in

a single estimate. The correct aggregate result is to calculate the total response as a weighted sum (average) of the stratified results, where the weights are the respective cell sizes of the different strata. Comparison of aggregate results from different studies may lead to erroneous conclusions if the relative cell sizes of each stratum differ across studies, even if the coefficients compare well at the disaggregated level.

IV. EVALUATION

This section evaluates eight empirical studies of the demand for higher education in the United States. Each study is briefly described and then is assessed according to the five criteria set forth in Sec. III.

HOENACK (1968a)

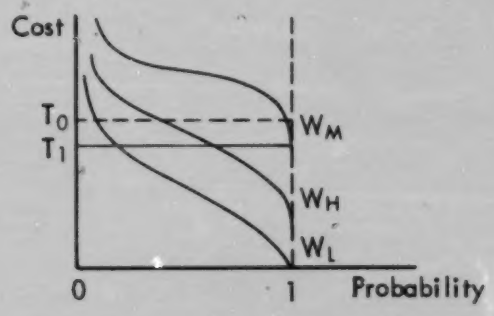
Hoenack's dissertation, one of the earliest studies of demand for higher education, provides a set of testable hypotheses. It attempts two tasks: (1) formulation of a policy model by which college administrators can allocate a fixed financial aid budget among students to achieve a desired distribution of income classes, and (2) estimation of the demand parameters used to evaluate alternative distributions of financial aid in the policy model.

The policy model begins with an allocation of a fixed financial aid budget among different groups of students indexed by their family income. If administrators desire a particular distribution of these groups in their institutions, the optimal allocation can be determined by standard utility maximization techniques. The decision rules derived from this exercise indicate that the ratio of the marginally effective subsidies of two groups should be proportional to their relative importance in the administrators' preference function. The term "marginally effective subsidy" points to the fact that the different groups may show different price-responsiveness to a given subsidy. To determine the correct subsidies to each group for efficient allocation, the separate demand elasticities must be estimated.

In Chap. 2, Hoenack develops a comprehensive model of individual and aggregate demand for higher education. The model resembles an investment model with a limited capital market. The assumption of limited capital markets is not only realistic but also allows the generation of testable hypotheses on the effects of income. The results of the model are stated as changes in the overall utilities of pursuing alternative college options (investment prospects) relative to the null option of attending no college. The model itself does not include specific variables such as tuition, wage rates, or expected wealth increments accruing from a college education. Rather, it shows how differences in the levels of consumption between the investment period and the payoff period alter the choice among different prospects for individuals of different income levels. The effect of specific variables can be evaluated by determining how they alter the ratio of future to current consumption for an individual. Specific results of the model include the following:

- As wealth increases, individuals are more likely to choose options whose costs and payoffs are relatively high. That tendency follows from the segmentation of the investment period due to the limited capital market assumption and from the assumption of the diminishing marginal utility of wealth.
- Options that cost less than other options are ranked higher in overall utility--a negative price response.
- The "critical cost," defined as the difference in investment cost that will equate the overall utility of two prospects, increases as wealth increases. This result follows from the assumption of lower time preference among higher-income persons, which causes them to evaluate the future benefits of a prospect as greater than would a lower-income person.
- An increase in loans increases participation in prospects that are more costly and that yield higher payoffs.
- The effect of improved employment opportunities is mixed in a world of limited capital because both foregone income and current (part-time) earning power increase.

When the individual demand relationships are aggregated to generate a market-demand curve, a relation of a particular shape emerges. Hoenack assumes a unimodal distribution of the critical costs of, say, option A over the null option, where the distribution reflects the frequency of individuals expressing positive demand relative to all individuals eligible for that option. When this unimodal frequency distribution is cumulated over all individuals, the resulting market-demand curve is S-shaped. The figure below shows the demand curves generated for persons of high, middle, and low income under two tuition policies. The implication is that an equal decrease in tuition yields different responses in the different income categories.



The policy-relevance of these results is that different subsidies must be allocated to different income groups in order to achieve equal representation for all income classes. In particular, the marginally effective subsidy for low-income students should exceed the subsidy to middle-income students. If the original distribution is overrepresented with higher-income students, little or no subsidy is required to maintain their numbers in the final distribution.

Treatment of Higher Education as Consumption Item or Investment

As indicated above, the model starts from the perspective of an investment model assuming a limited capital market. That assumption pervades the empirical implementation of the model. For example, a general formulation of the investment model would assert that the choice among options is subject to two constraints: (1) the present value of the net benefits of the choice must be positive, and (2) the total direct cost of the investment must not be larger than the individual's income plus his savings during the investment period. In Hoenack's empirical implementation, however, only the second of these constraints is recognized. No measure of the expected wealth increment accruing from a college education is included in the model. Exclusion of this variable assumes that the wealth increment is the same for all college options, or that the wealth increment measure is uncorrelated with all other variables in the model. To the extent that those assumptions are not valid, the estimates of the coefficients of the variables will be biased. A positive correlation with tuition will bias the coefficients of that variable away from zero. Exclusion of the expected-wealth-increment variable would be valid if the individual's subjective discount rate were so high that it ruled out consideration of future benefits. But then the model would revert to a one-period consumption model.

Hoenack's model does include several variables important for measuring the effect of the second or financial constraint. Among them are the tuition and transportation cost of attending several types of higher educational institutions in California. Also included are the average unemployment rate, the average wage rate, and median family

income--measured for the locality of the individual's high school. The level of unemployment and the average wage rate measure both the opportunity cost of withdrawing full-time from the labor force and the income that could be obtained by working part-time while attending college. Recall that because of the confluence of these two effects, no strong hypotheses were advanced with regard to the sign of the estimated coefficients of these variables. Family income measures the average ability to finance the direct cost of a college education. One might assert that the coefficient of this variable also measures the value placed on the nonmonetary benefits of a college education. On the assumption that these benefits are valued as a normal good, their effect would reinforce the positive effect (through the financial constraint) that income would have on choosing a relatively costly option like the University of California. An important aspect left out of the cost-of-attendance variable is a measure of financial aid expected from the various institutions. This omission is serious because much of the variation in the cost of attendance at the various campuses in Hoenack's data derives from estimates of the transportation cost from the student's residence (high school) to the campus. To the extent that these measurements are incorrect or that an individual's response to transportation cost is systematically different from his response to tuition cost, the coefficients estimated for the cost variables will be biased. A similar procedure for measuring travel costs was used later by Hoenack and Weiler (1975), discussed below.

Selection of the Choice Set

The choice set represented by Hoenack's empirical model is a

two-stage decision model. The first stage is the decision to become eligible for admission to the University of California system. It must be made several years before graduation because the student must take preparatory courses appropriate to the the university curriculum. The second stage is the eligible student's choice among the systems and colleges within systems. In California there is the UC system, the state university system (SU), and the junior college system (JC). Presumably UC eligibility implies eligibility for the other systems. Hoenack gives separate costs for attendance at all the major campuses of the UC system but only the cost of attending the nearest campus of the other systems. The cost of attendance includes the incidental fees and the travel cost. The fact that only the nearest campus of non-UC systems is represented implies that the decision process treats components of non-UC systems as perfect substitutes, except for distance. The wage rate is included to represent the no-college option.

Does the specification adequately represent the choice set available? One could assert that undergraduate public education in California is relatively homogeneous across campuses in courses offered. Therefore, for a particular student, the distinguishing characteristic among campuses would be their relative cost.* However, to say that cost alone distinguishes among the various campuses is to say too much, for choices based on cost alone would always lead to selection of a junior college if the fees and travel cost were uniformly lower than at

*The practice of focusing only on the factors that differ among choices is an application of Tversky's model of "elimination by aspect," an attempt to formulate conditions under which the choice set can be restricted without producing bias in the estimated coefficients. For a discussion of this model, see Tversky (1972).

the other campuses. Clearly, what is represented by the specification is a choice among institutions with regard to their quality (or income-producing potential), subject to the financial constraint. Viewed thus, the cost variable serves two purposes: (1) a proxy for the quality of the school and (2) a measure of the effect of the financial constraint. Therefore, the estimated coefficient measures the response to both factors.*

The omission of private schools in the choice set also impairs the specification. Unless one is prepared to assert that the choice between public and private colleges does not affect the choice among components of the public colleges, the estimated coefficients based on the restricted choice set will be biased.

Measurement of Financial Aid Offers

The specification does not include any measurement of financial aid. Because some high schools in the sample may systematically receive higher or more frequent awards of financial aid, the coefficents for the cost variables will be biased.

Identification of Demand/Supply Relationships

Hoenack relies on the specific definition of his "price" variable to establish identification. Since the variation in the cost variable is largely due to differences in distance, he asserts that price is independent of demand. He also argues that all persons included in the dependent variable are, in fact, eligible, so the terms of supply are

*Hoenack recognizes this point on p. 10 of his dissertation.

exogenous in the demand equation. This formulation might be considered a special case of class 2 models discussed above (p. 17), where P is not only predetermined but completely exogenous.*

Use of Stratified Estimates

Hoenack is interested in evaluating the effect of different policies related to the use of financial aid to achieve equality with respect to classes he stratifies on income. The differences across income classes appear to be significant. However, the estimates are not cross-classified on the basis of ability. Thus, if in fact individuals of different ability respond differently, forecasts based on Hoenack's coefficients could be biased. In fact, no measure of ability is included in the entire specification, so if ability affects demand and is correlated with other variables, a further source of specification bias is likely. In particular, if ability is correlated with income, then the effect of income in the stratified estimator will be biased.

HOENACK AND FELDMAN (1969)

In a study for the Institute of Defense Analyses, Hoenack and Feldman applied the demand model in Hoenack's dissertation to a different sample of data. The estimates are based on a cross-section of 1960 Project Talent data with follow-up information. The model focuses only on the college/no-college decision, but it is estimated separately for men and women.

*If the constructed variable is not representative of the true price variable, bias enters because an explanatory variable has been excluded.

The theoretical section presents an hypothesis characterizing the differences in demand response by sex: Men and women are expected to respond similarly to high-cost options but differently to low-cost options, with women being less responsive to tuition changes. The hypothesis follows from three assumptions about the different preferences of men and women: (1) men expect higher monetary returns from a college education since they are more likely than women to offer their skills in the marketplace, (2) men and women have the same expectations of nonmonetary benefits, and (3) monetary and nonmonetary returns are more positively correlated for women than for men since women enter the labor force primarily to receive nonmonetary benefits but also gain the monetary benefits. Men enter the labor force primarily for the monetary benefits whether or not they expect to derive nonmonetary benefits.

To get from these propositions to Hoenack and Feldman's conclusion requires the additional unstated assumption that both sexes have equal access to a perfect capital market.* For both sexes, high-cost options are then financed out of the income differential due to college training where the financing is derived from the capital market. That is, only high income differentials will finance the high cost of schooling via the capital market, so men and women are equally sensitive to changes in those costs. For low-cost options, future income is not a crucial factor in financing present costs, so women can enter college for only

*For high-cost options we are talking about either capital market financing or persons of high income. Neither men nor women are likely to be particularly price-sensitive if they are from high-income groups since they are not as affected by limited capital markets. Therefore, for lower-income groups, differential access to capital markets is of some importance.

the nonmonetary benefits. As a result, women are not as sensitive to changes in the cost of college when the cost is already low. Men, on the other hand, generally expect to work, and their calculations of present value always have a significant monetary component. This component is sensitive to changes in college cost at all levels of cost. Hoenack and Feldman therefore argue that men are generally more sensitive to changes in college cost than women (p. 8).

If the assumption of equal access to financial markets is altered to allow for more difficult access for women than men, women then appear more sensitive than men to cost changes at high levels of costs because they cannot finance increases as readily. Another condition that will produce the same result is sex-related discrimination in wages for women, making their expected monetary benefits for a given prospect less than for men. In this case women also have more difficulty obtaining enough financing even if they have the same access to the financial markets as men. Thus, considering high- and low-cost options together, the differential sex effects may cancel each other out. Only by distinguishing between high- and low-cost options would the distinction by sex be apparent. Given the outcome just described, there is no longer a strong a priori hypothesis about differences in demand by sex. Except for that hypothesis, the conclusions of Hoenack's earlier model are carried over intact.

Treatment of Higher Education as Consumption Item or Investment

Though the general theoretical framework is derived from Hoenack's dissertation, the set of explanatory variables differs somewhat from that of the earlier study. A significant addition is the average of

students' test scores by state. The scores were obtained from the Project Talent test battery administered to all survey participants. The coefficient of this variable is a measure of the expected benefit of a college education if aptitude is positively correlated with success at college. Other variables in the specification reflect the financial constraints and include labor market variables, tuition at various types of schools, and education of parents as a proxy for family income. The proxy, which involved a complicated derivation, was used because the income data from Project Talent were known to have many errors. The specification also included several conditioning variables such as regional dummies, urban/rural composition, and interaction with other variables in the model.

The actual functional forms of the estimates, given in an appendix, are rather surprising. Each of the explanatory variables is entered alone linearly, and several are also included in complex interactions that defy clear interpretation. There is no theoretical justification for the form of the interactions, and they do not follow from any of the implications of Hoenack's theoretical framework. The only justification is that all interactions had to satisfy certain a priori sign restrictions and achieve at least a 90 percent confidence level on a two-tail test of significance. Policy results are evidently derived by differentiating the result equations with respect to each of the policy variables. Because of the complexity of the interactions, the policy results are not as clear as they could be. For example, the reported results have been derived by differentiating with respect to tuition and by letting the values of ability and income vary over the appropriate ranges. But tuition, income, and test scores also

interact with several other variables. The derivative evaluations mean that these other variables must be fixed at some specified value. It is not clear how sensitive the results are to the selected values of these other variables. The counter-intuitive results of higher demand elasticities associated with higher income for changes in 4-year public tuition may have been produced by holding a particular configuration of the other variables constant at arbitrary values.

Selection of the Choice Set

The specified choice set involves a binary choice, to go or not to go to college. The dependent variable is based on the proportion of tenth graders completing the Project Talent questionnaire in 1960 who attended an institution of higher education the year after graduation. Since the questionnaire was to be administered to all tenth graders, we may take the denominator of the proportion to represent the universe of tenth graders in 1960. The proportions are calculated for each state and then are converted to the "logit" method.*

The authors emphasize that since the survey is based on the subsequent decisions of tenth graders, the results should be interpreted as long-run responses. They are long-run in the sense that changes in tuition can influence decisions throughout the junior and senior years of high school. Therefore, the estimated coefficients reflect all these decisions.

*The "logit" method is an estimating technique developed by Berkson (1944, 1953): If P is the estimated proportion of attendance by state, the estimating equation is given by $\ell n(P/(1 - P)) = X'B + u$. This formulation allows estimation of a cumulative probability function in which the predicted values of P are bounded in the interval (0,1).

The choice set represented here aggregates all types of colleges in the dependent variable. This confuses the interpretation of the coefficients if the mix of different types of colleges varies across states. Furthermore, the choice of going to college may depend on the set of colleges available to attend. In addition, a technical problem is associated with using the logit procedure on data where the right-hand variables are constructed from observations within states. The original use of the procedure was in controlled experiments of bioassay. The proportions used as the dependent variable were calculated across sets of observations, each of which represented exact replications of a given treatment configuration. In the present case the explanatory variables for a given state are not exact replications of all individuals in that state. To the extent that explanatory variables within states vary more than do explanatory variables among states, the estimated equations will show bias.*

Measurement of Financial Aid Offers

The specification includes separate measures of scholarship availability. The total amount of aid funds disbursed through junior colleges, private colleges, and universities was divided by the total population of 17-year-olds in the state to obtain an estimate of the expected award from each type of institution by state. The use of state-specific price and aid variables provides a measure of the mix of opportunities in each state.

*McFadden (1974), p. 119. For discussion of a possible adjustment for this type of problem, see McFadden and Reid (1974), pp. 13-18.

Identification of Demand/Supply Relationships

Hoenack and Feldman take pains to justify their assumption of a perfectly elastic supply curve. They argue that the supply curve is dependent on two components, resource costs and the willingness of the public to subsidize higher education through low tuition charges. It is further assumed that resource costs vary independently with respect to demand variables across states. The authors tested for the presence of a relationship between family income and tuition at public colleges; they were not able to reject the hypothesis of no correlation. The test merely examined whether both demand and supply relationships moved in the price-quantity space in response to changes in income. The acceptance of the null hypothesis then justifies a class 2 model, where the determination of tuition is completely exogenous to the demand relation.

Use of Stratified Estimates

The use of interaction terms in the functional form allows derivation of results comparable to those derived from stratified estimates. In fact, the Hoenack and Feldman specification allows a three-way classification of the coefficients: sex by income class by ability. Further stratification of the dependent variable by type of college, and separate reporting of results, would have been helpful, however. The aggregate specification gives only the net change in overall enrollment for a given change in tuition and does not allow examination of the substitution between college types.

HOENACK AND WEILER (1975)

Hoenack and Weiler's study focuses on a policy issue different from that in Hoenack's earlier work. Here they evaluate the effect of imposing a "cost-related" tuition policy, an attempt to apply average cost pricing to students enrolling in different colleges of a university.* The benefits to society of such a policy would be similar to those deriving from the standard price-allocation model under assumptions of perfect competition and perfect information. The mechanism presumes that a student correctly evaluates the relative returns of different courses of study and chooses a college within the university accordingly. University officials, in turn, receive demand signals and establish courses and set prices for curricula so that (in this case) the average cost of a curriculum is covered by the tuition from individuals pursuing that curriculum. To the extent that conditions of perfect information obtain, students make correct evaluations; university officials provide the right courses, which are then priced correctly; and resources in higher education are correctly allocated.

Toward the end of the study the authors suggest that universities might benefit financially from a cost-related tuition policy because revenue would increase more than costs. They then advocate that the legislature continue to fund the university on a flat per-student rate so that the extra revenue generated under the new tuition policy will

*The authors acknowledge that basing cost-related tuition on marginal cost would present severe conceptual and measurement problems. They point out, however, that average costs can be readily measured, and the appropriate changes in tuition based on average cost can be effected as total enrollment changes (p. 336).

remain under university control. One wonders why the monetary benefits due to the policy should all be concentrated in the hands of the university and not returned to society as additional services in areas other than higher education or as lower taxes. It is not clear that the resulting allocation of resources would be better than the previous allocation.

For the empirical implementation of the model, the authors estimate demand relations for attendance at the Minneapolis campus of the University of Minnesota. Since the policy model is concerned with cost-related tuition established separately for different colleges within the university, separate estimates are given for the College of Liberal Arts, the Institute of Technology, and the General College, among others.

The main difficulty occurs in the measurement of costs used to calculate the demand response parameters. Since all observations pertain to the same school in the same year, the sample does not include any variations in tuition charges. Instead, distance from the student's residence is used in the equation as a proxy for cost of attendance. The response to distance is then transformed by assumed values of (1) the value of time, (2) rate of travel, and (3) number of trips per year, to arrive at a dollar cost. Uniform values for all these factors are assigned to each student so that the sole variation in cost of attendance is in the distance to be traveled. In addition, the cost of attending alternative schools is measured by their distance from the student's residence. If all students were commuters, that procedure would be acceptable, because each student would have about the same number of trips as all other students. But in order to secure variation in similar measures of cost to the other types of institutions, the authors included some noncommuting students

in the sample. While one might accept uniform values for the value of time and perhaps for the rate of travel, it strains credulity that all students would make the same number of trips per year. The bias in an estimated coefficient for a variable measured with error is proportional to the ratio of the variance of the error of measurement to the variance of the variable measured. That is, for the classical errors in variables model, if the variance of measurement error is 10 percent of the variance of the number of trips, then the estimated coefficient will be biased downward by 10 percent.*

That the authors acknowledge the possibility of bias does not alleviate the problems, and in this case the bias is severe. The problem is compounded because a distance proxy is used for all cross-price responses in the model. The assignment of a uniform quantity for number of trips means that the true variable is not in the model. Since the number of trips is likely to be correlated with other variables included in the model, all coefficients are thus biased in directions depending upon the direction of correlation. The authors' "sensitivity tests"--which utilized alternative values of number of trips and value of time but still applied them uniformly to the whole sample--do not test the adequacy of the specification; they only change the scale of the coefficient. In addition, apart from

*The classical model does not strictly apply here since it assumes that there is no covariance between the degree of distance and the number of trips. The authors concede that such a covariance exists and that the sign of the relationship is, of course, negative. Another source of covariance in the measurement error is between the error and other explanatory variables in the analysis. For example, holding distance constant, the number of trips is likely to be positively correlated with family income. The complexity of the errors introduced by this specification preclude analysis of the direction or magnitude of biases in the resulting estimates.

the measurement problems, the authors implicitly assume that the response to changes in travel cost will be identical to the response to changes in tuition.* While measurement error is present to some extent in most studies, and omitted variable bias is also a common problem, the potential for bias in this study is unusually great.

An attempt was made to justify the reasonableness of the estimated demand response by comparing it with the results derived from a time-series analysis of enrollments in the College of Liberal Arts. The two results agreed quite closely. However, the relationship between cross-section and time-series results is often difficult to resolve; fortuitous agreement does not justify specification errors in the cross-section estimation. While the results are interesting, more evidence is needed to verify the assumptions of uniformity of number of trips.

Another interesting time-series analysis is included. The continuation of students from the freshman to the sophomore class, from the sophomore to the junior class, and so forth was analyzed as a function of family income and tuition. The results suggest that changes in tuition only affect the freshman-to-sophomore transition; later transitions are negatively affected but not significantly so.

The authors analyze an issue associated with a cost-related tuition policy. It is asserted (no evidence is provided) that elasticity of response to tuition is positively correlated with ability in the

*Results reported by Bishop indicate substantial differences in responses to travel and room and board costs compared with tuition cost in estimates based on the 1960 Project Talent data. See below and Bishop (1975), p. 20.

sense that students of higher ability are more likely to seek other educational alternatives (and presumably be accepted) in response to a tuition increase than are students of lower ability. It follows that under a cost-related tuition policy where tuition for graduate students would increase markedly, the quality of the graduate enrollees would decline. The point of the exercise is to determine how much quality would decline with, say, a 50 percent increase in graduate tuition. Two subsidy programs were advocated to counteract the expected decline in quality; the first program would exempt the top 10 percent of the graduate class from the tuition increase, and the second program, the top 20 percent. A further assumption was that the supply of graduate students to graduate schools is essentially perfectly elastic, so total enrollment was not expected to fall.*

Evidently the data for the analysis came from applications filed in the graduate and professional schools where high school GPA and Graduate Record Exam results were available. The simulation of both exemption programs suggested that quality would not decline markedly. The outcome of the simulation was in a sense predictable because the authors assumed only moderate tuition elasticity for the students of lower ability not exempted. Thus, just a few of them would be expected not to enroll because of the tuition increase. The most striking result was that the distribution of GRE and GPA scores of individuals not accepted but on file at the university was not radically lower than that of the students who were accepted. Thus, not only is the supply of applicants perfectly elastic but also the supply of an acceptable quality of applicant

*Evidence of relatively high applicant-to-admission ratios was presented to support this assumption.

is relatively elastic. The validity of the simulation results depends, of course, on the validity of the assumption about the correlation between elasticities and ability. Bishop's stratified results from the Project Talent data show mixed responses across ability groups. If anything, tuition elasticity falls as ability increases from the upper-middle ability quartile to the top ability quartile.*

Finally, a simulation was conducted of the effect of a cost-related tuition policy on the distribution of enrollments at the various colleges within the University. First, the existing enrollment distribution showed the relation between total revenue and cost for each college by class level. Second, a new distribution was calculated to show the effect of setting tuition at 25 percent of the costs. Under this policy, changes in tuition for students in different classes and different colleges ranged from 14 percent less to 65 percent more than original tuition. The largest increase occurred for graduate students. The outcome was calculated for both the 10 percent and 20 percent exemption schemes mentioned earlier. Under both programs the university showed a net gain in revenue of 2.8-3.4 percent.

Since the policy conclusions of the study depend primarily on the empirical results of the cross-section analysis, the following evaluation concentrates on that portion of the study.

Treatment of Higher Education as Consumption Item or Investment

The theoretical framework of this study is not explicitly stated. Previous research is referred to in a footnote. The explanatory variables

*See Bishop (1975), Table 2, p. 27. These results also apply to undergraduates.

include income, a proxy for the cost of attendance, and ability. Except for the latter variable, the focus is on the financial constraint. Ability is measured by a test score and the student's percentile ranking in his graduating class. The effect of the latter variable is likely to be ambiguous unless variance of ability within schools far exceeds variance between schools. The ability measure is an attempt to include a variable to reflect a student's potential for success in college, which may influence the size of the income increment due to the college training.

Selection of the Choice Set

The choice set represented by the model is severely restricted. No measure of private schools or a no-college alternative is included in the explanatory variables or as dependent variables in a polytomous choice framework. The use of distance to represent the relative cost of attendance at schools other than the University of Minnesota is likely to produce substantial measurement error, as indicated previously. It is just not reasonable to assume that the relative costs of attendance among several college alternatives are proportional to the colleges' relative distance from a student's residence. Nor is it reasonable that all students would make the same number of trips to each university, state college, and junior college.

Measurement of Financial Aid Offers

No account is taken of financial aid offers in the specification.

Identification of Demand/Supply Relationships

The identification problem is not treated in the study. Evidently

the authors rely on either the recursive argument or independent determination of the terms of supply to identify the demand relation and enable consistent estimation by OLS.

Use of Stratified Estimates

The only stratification in this study was among colleges within the Minneapolis campus. No test results were shown to indicate whether the separate equations were significantly different. On the other hand, it is regrettable that stratification was not done on ability or income; there were certainly enough observations. The simulations of tuition-related quality decline in the graduate school would have been better if they had been based on actual estimates of tuition elasticity for different ability levels.

CORAZZINI ET AL. (1969)

The Massachusetts State Board of Higher Education, in cooperation with the Boston Metropolitan Area Planning Council, produced a study that addresses a broad set of interesting policy questions in a unified framework. The initial proposition is that each student who completes high school is a potential college student. Students who do not pursue postsecondary education are prevented by one or more constraints, primarily lack of aptitude and lack of funds. The study examines these two constraints to identify how policy might be applied to reduce their effect. The authors addressed the first constraint by studying the impact of school inputs on motivation and on aptitude test scores. They studied the second constraint by examining the results of a national demand model and a survey in the Boston area to

determine what forms of financial aid would be most effective for students from families of different incomes.

The authors begin with an analysis of three national surveys: Project Talent (PT), Equality of Educational Opportunity (EEO), and two U.S. Bureau of the Census surveys (BC). The BC surveys, administered in 1959 and 1965 to high school seniors, reveal substantial differences over time in the aspirations of children of poor parents toward college attendance. In fact, the proportion desiring to attend college doubled in this six-year period. The EEO survey showed that more low-income students who also had low measured verbal ability had aspirations for college than did high-income students of low ability. That is, students constrained both financially and in aptitude saw college as a desirous alternative more often than did students who were constrained in aptitude but not in finances.

The analysis of the PT data was cast in the form of a demand study (to be discussed in detail below). The results confirmed that financial and aptitude constraints are effective barriers to college enrollment and that the effects differ across socioeconomic and sex-defined strata.

The Boston survey, which sought information comparable to that in the PT survey, was given to a random sample of college-bound and non-college-bound seniors in public and private schools. Provision was made for the follow-up of students; the later results have not yet been published.

The Boston survey results can be summarized under two headings, student aspirations and student plans. Aspirations and plans were cross-tabulated with sex, type of high school, income, and ability level. Nearly 70 percent of all students surveyed expressed a desire to go to college, and 19 percent aspired to other (noncollege) postsecondary

training. Aspirations for college were not particularly sensitive to family income; 60 percent of the low-income students also aspired to college. The strongest influencing factor was parents' educational attainment. Students in private high schools tended to desire college training more than did those in public schools, but public students in college-preparatory curricula showed a stronger preference for college than other public students, as one would expect.

College plans were highly related to college aspirations. Differences observed in the analysis of aspirations were accentuated in the plan responses. High-income students were more likely to have definite plans for college than low-income students. This was true for the low-ability set as well, suggesting that higher income may substitute for lower aptitude. Students following college-prep curricula also had more definite plans.

In studying the failure of the Boston students to attain their aspirations, the authors found that the financial constraint was identified by only 3 percent of the students who desired to go to college but were unable to do so. However, among those who did not aspire to college training, it was clear that the main reason was the cost. Therefore, the results suggest that desire as well as plans are affected by cost.

The most common constraint was aptitude. Since aptitude is measured primarily by the Scholastic Aptitude Test (SAT), the authors explored the observed distribution of scores by family and school characteristics. They found that much of the variance in the SAT scores could be explained by these factors. The important school characteristics were expenditures per pupil and age of the teaching staff; students of the younger staff generally had higher SAT scores.

This last point is particularly interesting. It suggests that the main constraint on fulfilling college aspirations is measured aptitude (i.e., the SAT score) and that this score is controllable by policy. Therefore, to the extent that financial aid programs are designed to equalize educational opportunity, they should not be distributed on the basis of the SAT scores as though they measured actual ability. It appears that the SAT measures instead the very factors that limit educational opportunity--poor schooling and nonsupportive family.

In their conclusions, the authors outline a three-part student aid program designed to address the financial and the aptitude constraints. The first part is a direct grant for higher education distributed on the basis of financial need. In the second part the student may choose a loan whose repayment depends on income or a work-study program or both. This program would probably meet the needs of middle-income students who face a limited capital market but are willing to borrow against future income. The third part is a loan of fixed repayment, the terms depending on financial need. It is designed for the low-income student who is hesitant to borrow against future income that he cannot imagine attaining. The authors suggest that aspects of the three programs could be mixed according to the student's preferences and financial need.

The following detailed evaluation pertains to the analysis of the Project Talent data.

Treatment of Higher Education as Consumption Item or Investment

The authors use the general investment-consumption model as a point of departure. They particularly recognize the importance of the

expected return on a college education as a motivating factor. However, much of the theoretical richness is lost in the empirical specification. The authors acknowledge the disparity and attribute it to limitations of the data. The set of explanatory variables encompasses all major categories of choice, including the nature of the labor market. Ability is used to account for the expected return on education, but the authors recognize that the coefficient of this variable may be biased upward if colleges use ability as a selection criterion. In giving the regression results, the authors state their reservations about the outcome in some detail and indicate sources and directions of potential bias.

Selection of the Choice Set

Despite the stated intention of estimating separate equations for several types of institutions, the results appear to pertain to the aggregate of postsecondary educational institutions. Therefore, the choice set represents only a binary choice: to go or not to go to college. The choice set is misspecified in the first place because the decision to enroll in any type of postsecondary institution is likely to be related to the mix of such opportunities available in different states. Second, because the mix varies across states, the price coefficients for the aggregate equation will reflect both the composition effect and the price effect and will therefore be difficult to interpret. The authors did represent most aspects of the relevant choice set in the list of explanatory variables, but they did not use a polytomous technique to account for a more general choice set. It is also questionable whether prices alone sufficiently describe the decision process among alternative choices.

Measurement of Financial Aid Offers

No account is taken of financial aid offers.

Identification of Demand/Supply Relationships

In a footnote the authors assert that the terms of supply in each state are exogenously determined and therefore that the demand equation is identified. No support is given for the assertion. If the authors' speculation about the rationing role of the ability variable is correct, the coefficient of this variable will show a simultaneous equations bias, as was indicated above.

Use of Stratified Estimates

The equations are estimated according to two separate stratification schemes. The first divides the sample by sex, and the second by socioeconomic status. No stratification by ability is given. In the stratification by sex, men were more responsive than women to changes in tuition, parental education, and labor market variables. In the socioeconomic status stratification, the lower quartile showed more responsiveness to parental education and labor market variables than did the other quartiles.

BISHOP (1975)

The purpose of Bishop's study is to furnish estimates of individual students' demand responses stratified by income and ability. The estimates are derived in a rich theoretical context that allows for inferences regarding several important issues surrounding the decision

to enroll in postsecondary training. The results show ability- and income-specific responses to the availability of different types of colleges, tuition policies, admissions policies, the nature of the student's social environment, and the availability of student loans.

In a policy model, the author gives the rationale for using tuition policy as an instrument to promote equality of opportunity. Equality is defined as a condition in which persons of approximately equal ability have the same probability of attending college. The model uses a result from Baumol and Bradford (1970) to show that a policy of uniform tuition is inefficient given the foregoing definition of equality if income elasticities differ across income classes. Hoenack (1971) obtained the same result with a more restricted policy model. Hoenack's model required that the education budget be fixed, and he defined equality as the enrollment of equal numbers of students from each income class. Bishop's model equalizes probabilities from each class and fixes only the shadow price of the government budget constraint.

The theoretical section of the study perceives the college-going decision as an investment model with imperfect capital markets. Two conditions must be met before a student enrolls in college. First, the present value of perceived benefits must exceed the perceived costs of the education. The factors entering the condition are (1) the costs of attendance, including tuition and living costs, (2) foregone earnings, (3) the present value of the wealth increment that will accrue from the extra training, and (4) demographic factors. The second condition is that current income plus savings plus family contributions must exceed the current direct costs of the schooling. Bishop expresses the

probability of going to college as a dichotomous logistic function that depends on a linear combination of the two conditions. The estimates are derived with a maximum-likelihood estimating technique.

The results present the effects of selected variables for 20 ability/income strata on the logit or log odds of enrollment. In addition, selected policy options are evaluated with respect to their impact on the percentage of high school juniors who eventually attend college. Finally, the effects on enrollment probabilities of using efficient tuition policies to achieve equality of opportunity are evaluated under different assumptions of the tightness or ease of the government budget constraint.

Treatment of Higher Education as Consumption Item or Investment

As mentioned above, the author perceives the college-going decision as an investment model with imperfect capital markets for educational loans. The implications of the imperfect capital markets are explicitly developed and carried into the empirical formulation. First, the market for educational loans either presents an interest rate higher than the prospective student's subjective time preference rate, or restricts the number of loans offered at a lower rate. Therefore, the market rate will be replaced by the student's subjective discount rate in calculating the net benefits of different options. These subjective rates will be conditioned by the student's circumstances and by the prevailing attitudes in his home, school, and community.

The second implication of an imperfect capital market is that an additional constraint is imposed on the decision process. The chosen postsecondary program must be financed out of current savings, income,

and family contributions. Consequently, the student will have a lower level of consumption during the investment period than he would if he chose the no-college option. Only the joint satisfaction of the benefit and financial constraints will lead to a decision to enroll in college.

In the empirical formulation, the net benefit constraint includes direct costs (room and board and tuition), foregone earnings, the expected wealth increment due to a college education, and a set of proxies to account for other, nonmeasured factors that affect the evaluation of net benefits. The financial constraint includes the value of net benefits, direct cost, savings and current earnings, and a set of proxies to account for the size of family contribution. Net benefits are included in the financial constraints to examine how this quantity affects the size of the family contribution. The current wage rate enters negatively as a component of foregone earnings; in the financial constraint it enters positively as a component of current (part-time) earnings. The actual estimation procedure uses a dichotomous logit form, where the probability of attending college depends on a linear combination of the two constraints. By a rather arbitrary assumption the variable measuring the quantity of time spent in past and current part-time work is dropped from the analysis.

Several facets of the imperfect capital market assumption can be explored with the resulting specification. First, on the assumption of a perfect capital market, the wage variable enters only as foregone earnings, so the coefficient should be negative and approximately equal to the coefficient of direct costs. Second, if the financial constraint dominates, the coefficient of the wage variable should be positive because it enters only as current earnings. The actual impact of an imperfect

capital market can then be judged by the sign of the wage coefficient and its size relative to the direct-cost coefficient. Finally, the coefficient of the wealth-increment variable and the direct-cost coefficient provide an estimate of the lower bound of the student's subjective discount rate.

The specification is limited mainly in the lack of individual data for a number of variables. In particular, the wage variable and the wealth increment are based on regional averages, so some measurement error is inevitable.

Selection of the Choice Set

The choice set specified in the analysis follows from a two-stage sequential decision process. The choice among colleges is conditional on and independent of the initial decision to enroll in a college. The model only deals with the first decision, and cost is the sole basis of that choice, as is evident in the specification of the relevant cost variable.

The author asserts that the cost of the most inexpensive college available is the critical variable that distinguishes college-goers from nongoers. That is, if a student wants to go to college and can afford the lowest-cost college, he will go. An implication is that a student's plan to attend college will not be disrupted if tuition rises at other than the lowest-cost colleges. Therefore, only the cost of the least expensive college was included in the specification; coefficients of the costs of other colleges were arbitrarily assumed to be zero.

The choice of the least expensive college was subject to some restrictions. It had to (1) offer a broad range of programs, (2) accept

at least 20 percent of the state's high school graduates, and (3) be compatible with the racial and religious preferences of the student. The cost of attending a particular college depends partly on how far the campus is from the student's home. Given a constant number of trips, a constant speed of travel, and a constant cost/mile to determine travel and time costs, the cost of attending a school was evaluated for both campus residents and commuters. Whichever was least expensive was then assigned to that school. The minimum-cost college was found to be a public college in the student's home state, most likely in his own community. We have already pointed out the dangers of assuming constant numbers of trips to determine travel costs. In an early version of this study, travel, room and board, and tuition were all included in one variable; in a later version tuition was separated. The estimated price elasticities are likely to be severely biased if these unrealistic assumptions about travel costs are maintained.

Three other variables in the specification affect the choice set. First, the additional cost of attending a four-year college over the the minimum-cost college (MCC) is included. This variable measures the range of costs that the student is faced with. Second, admission requirements at the MCC are included as the percentage of the high school graduating class that is likely to be admitted. This variable measures the availability of spaces at the MCC given the student's academic performance. Finally, an indicator variable is included to estimate the effect on demand when the MCC is a two-year extension campus without vocational programs. This variable essentially measures the effect of the breadth of curriculum available at the MCC.

The choice set defined in the analysis is clearly restrictive since the range of options is not fully specified. The choice set is described mainly in terms of financial variables and pertains mainly to public colleges. Though the assumption of imperfect capital markets indeed heightens the influence of the financial variables, the availability of certain types of schools may offset the increased costs for some students. The author recognized this possibility in his discussion of the specification.

Measurement of Financial Aid Offers

No account is taken of financial aid offers. The author asserts that during the sample period, 1971, only small amounts of financial aid were available, so the omission of this factor from the specification will produce negligible bias in the resulting estimates.

Identification of Demand/Supply Relationships

The identification problem is not mentioned. Evidently the author assumes that costs were predetermined and that admission requirements were fixed before application.

Use of Stratified Estimates

The results give extensive information on differences in response to selected variables by ability and income strata, since the model was fitted separately for 20 groups of students. Moreover, the results indicate substantial variation across strata. For example, the tuition elasticity ranges from -.084 for high-income students to -.393 for poor students. The tuition elasticity also varies across ability groups, with

middle-ability groups showing more responsiveness than either high- or low-ability groups.

RADNER AND MILLER (1975)

At first glance, the Radner and Miller study appears to offer a single comprehensive analysis of many issues in higher education. Closer scrutiny reveals, however, that the study is actually a series of separate studies using different techniques on different data. The authors' stated purpose is to forecast the academic demand for Ph.D.s, estimate the human and financial resources needed to extend universal education through two years of college, and estimate the effects on demand for higher education of greatly increased resources for compensatory education at the elementary level. These policy analyses, however, are distinct from and do not depend on the demand estimates presented in the first five chapers of the book. The policy analyses are described below, followed by a more detailed discussion of the demand study.

Policy Analyses

Chapters 6 and 7 analyze the technological relationships (i.e., faculty-student ratio) within the higher education section. Chapter 6 examines the data longitudinally, 1950-1967, by type of college, and Chap. 7 examines the cross-sectional pattern of faculty-student ratios in 1966. Two models are estimated. The first, a fixed-coefficient labor function, relates the number of full-time equivalent faculty to a strict linear combination of full-time equivalent numbers of undergraduate and graduate students. The estimates are presented separately by college type. The second model allows the estimated

coefficients to vary within types of institutions depending upon faculty salaries and fraction of the faculty holding Ph.D. degrees.

Chapter 8 presents estimates of the stock of persons in the United States holding college degrees. The detailed tables show the numbers holding various degrees, by academic specialty, for ten-year intervals as well as the growth rate in each college class over the last 40 years. A particularly interesting analysis shows the average intervals between successive degrees for men and women. The results suggest that the inequality of past years in the distribution of advanced degrees between men and women is not decreasing. Thus, the current sexual inequality of access to employment requiring advanced degrees is not likely to be alleviated in the near future. Women simply do not attain advanced degrees with the same frequency or rapidity as men.

Chapter 9 focuses on the demand for Ph.D.s in the years 1970-1990. It examines recent projections and analyzes alternative policy changes that might be required of higher educational institutions in the face of excess capacity. The results support, at least qualitatively, the projections of Cartter (1971) and have implications for public decisionmakers, degree-granting institutions, and prospective doctoral students.

Chapter 10 develops a dynamic input-output model for calculating the implications of changes in enrollment and faculty-student ratios. The purpose is to provide background for the policy issues discussed in Chaps. 11 and 12. Chapter 11 uses the model to study the implications of extending universal education through the first two years of college. Chapter 12 studies the impact of significantly increasing the resources devoted to compensatory education in elementary schools. The two

policy changes would affect higher education in two ways. First, increased numbers of degree holders would be required to staff the increased educational activity. Second, the demand for college education would increase in general because a higher proportion of high school or two-year-college graduates would seek more educational training. Though the policy changes would tend to reduce the amount of excess capacity in the long run, it is hard to see how they could be implemented with existing resources or the distribution of academic specialties represented by graduate students now in college. The implication is that the crisis of excess capacity expected in the 1980s is still likely.

Demand Study

The paragraphs below discuss the first five chapters of the book and the material in Chaps. 2 and 3 of the technical supplement, Miller and Radner (1975).

Demand Model. The structure of the demand model seems to have been largely determined by the computational costs of using the McFadden conditional logit technique. The empirical work appears to be more an illustration of the McFadden procedure than a serious attempt to obtain the relevant parameters for policy analyses. That is because the style of analysis uses a highly restricted formulation of the demand model. First, the specification is restricted in the way the four explanatory variables enter the model. The cost of various alternatives is entered only in interaction with the income variable as a single cost-per-income variable. The formulation thus constrains the coefficients of costs and income so that they are equal in magnitude though opposite in sign. Similarly, student ability is entered only in interaction with the

various schools' selectivity level, so the coefficients of these two variables are constrained to be equal. Though such constraints may be warranted, they may also be inappropriate and result in biased coefficients.* The adequacy of the restrictions is not tested, and since the variables are not entered individually, it cannot be judged from the results.

The second limitation of the specification is the restricted nature of the list of explanatory variables. An attempt is made to account for the impact of excluded variables by an analysis of the estimated residuals or the restricted model. In this test the prospective explanatory power of a list of several categorical variables is examined by testing for the significance of mean residuals within cells defined according to values of the categorical variable. The tests indicate that the addition of several of the examined variables would improve the explanatory power of the analysis. However, none of these additional specifications is attempted, at least none is reported. Furthermore, no attempt is made to assess the degree to which the existing estimates are biased as a result of the excluded variables.** Therefore, not only

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*It should be noted that the McFadden conditional logit estimates do not allow student attributes to be entered except in interaction with school attributes. See McFadden (1974), p. 114, note 6.

**The presence of bias in the existing estimates can be illustraed for the transformed logit model, i.e., $Y = ZB$, where $Yi = \ell n(Pi/Pn)$ $(i = 1, n)$. Let the true specification be given by $Y = X_1B_1 + X_2B_2 + U$. Then let the actual specification be the following, where B_2 is set to zero: $Y = X_1b + e$. Then the expectation of b is given by $E(b) = B_1 + (X_1'X_1)\text{-}1X_1'X_2B_2$, and the expectation of the residual is given by:

$$E(Y - X_1b) = X_2B_2 - X_1(X_1'X_1)\, X_2B_2 = (I - M)\, X_2B_2$$

A test of the significance of the estimated residual vector depends only on whether or not B is significantly different from zero since the matrix $(I - M)$ is positive definite. What we do not learn, however, is whether the covariance of $X_1'X_1$ is zero, which is important because it determines whether the existing coefficients are biased.

do the tests indicate that the additional variables are appropriate to include in the specification but also that the restricted estimates should be viewed with caution because of possible bias. In addition, since the significance tests were conducted individually, the signs of the residuals do not give useful information because the residuals are also biased with respect to the other classifications. Thus, because of specification errors the results are at best only suggestive.

Procedure for Imputing Income. An imputed income variable was constructed at great effort. Examination of the responses regarding parental reported income across ability and student reported income strata revealed considerable response bias. Furthermore, student reported family income seemed to be inversely related to parental reported income for the middle and lower income classes. Therefore, it was necessary to construct an imputed income variable using other information from the sample.

The procedure adopted regressed a transformation of parental income on a list of parental occupation, education, and employment indicators as well as student reported income. The transformation was applied to the dependent variable to convert it to a percentile ranking in order to reduce the effect of the long tails of the income distribution. As a result, the dependent variable was converted to a cumulative distribution curve bounded by 0 and 100. A linear equation fitted to this dependent variable still does not predict well in the tails of the distribution, as the study results indicate. It would have been more effective to use a "logit" transformation of the percentile ranking.

Sensitivity Analysis. Chapter 4 attempts to extract trend information from the cross-section model by marrying the estimated

coefficients with speculations about their trends over the next 25 years. The authors say that they are trying both to make projections and to determine the sensitivity of the probability estimates to altered coefficients.

The speculated trends in the coefficients are just that; they appear to be derived from the speculations of other researchers about the state of higher education in the future. No time-series results are used to condition the trends imposed on the estimated coefficients.

The discussion also contains a logical fallacy. The authors want to justify the technique of altering the coefficients of the model; the difficulty is to guess which coefficients change and by how much. They resort to an aspect of the conditional logit model whereby the addition of an option not included in the original estimation will reduce the choice probabilities of included options proportionately. The fallacy occurs in supposing that that aspect (rather, limitation) is appropriate for assessing the course of the true choice probabilities over time. In effect, they are asserting that the greatest weakness of the conditional logit model (its flexibility in forecasting with a changed structure) is instead a virtue.

The authors conclude that the estimated probabilities of the demand model are sensitive to altered coefficients. Though for the reasons stated above one cannot accept the trend analysis at face value, the sensitivity of the choice probabilities to changes in the coefficients suggests that the considerations of bias discussed above for the demand model apply in judging the usefulness of these results as well.

Treatment of Higher Education as Consumption Item or Investment

No formal theoretical justification is given for the choice of

variables or for the manner in which they are included in the specification. The two variables address two aspects of the demand for higher education. The cost/income ratio refers to either or both the net benefit calculation and the current financial constraint; the separate effects cannot be determined from the single estimated coefficient. The second variable is entered as the product of student ability and institution selectivity. It appears to measure expected risk of failure, supply restrictions, and ability-related aspects of the demand for education. Again, separate implications cannot be drawn from the single estimated coefficient. The presentation of the functional form seems intended mainly to justify the predictive ability of the specification rather than to present tests of specific behavioral hypotheses; however, no tests of the overall fit for different specifications are given.

Selection of the Choice Set

As was indicated above, use of the conditional logit procedure for large problems may be very costly. The costs increase linearly with the size of the specified choice set over the sample, so it is prudent to represent the choice set as simply as possible, consistent with identification of the actual choice sets that people face. Radner and Miller's procedure is to classify all types of school options into nine representative groups, adding a tenth no-college option. The cells of the school classification are defined as combinations of three levels of selectivity and three levels of cost. The ten options are thought to represent the universe of options possible for all students. However, some students may not have access to the complete choice set. For example,

low performance on an achievement test may preclude admittance to highly selective options. Alternatively, since attendance cost depends on transportation cost, a low-cost option may not exist if there are no low-cost schools in the student's community. A student may have at most ten items in his choice set, but he may also have fewer.*

The adequacy of the choice-set specification hinges, of course, on the extent to which the constructed set represents the actual choices faced by individual students. Where possible, Radner and Miller inserted actual schools rather than averages of several schools in the cells of the classification. For example, only the actual choice of the student was inserted in the cell to which it belonged. Also, the low-cost options were generally specified as single local public institutions. Other cells were constructed as averages of more than one school that fit the definition of the cell. The use of individual school data instead of averages improves the representativeness of the constructed choice set.

A crucial question, however, is whether a two-way classification provides enough dimensions to adequately describe the decision process. For example, if the choice set contains several public options, they will not vary much in cost unless differences in transportation cost are also included. Decision theory suggests that preferred choices are identified on the basis of distinctive attributes, not attributes that are alike across options.** In the absence of these distinctive factors, a specification allocates undue weight to the attributes included, leading

*An implication is that the estimated coefficients for conditional logit models depend on the distribution of choice sets in the sample being investigated.

**Tversky (1972).

to biased estimates. Further research is required to determine whether Radner and Miller's specification accurately discriminates among options.

The authors represent the student's entire choice as a one-stage procedure, though with some misgivings after having read Kohn, Manski, and Mundell (1974). The latter use a two-stage model in which the decision to go or not to go to college is made after determining the preferred college if one were to go. Some investigators use a different type of two-stage model where the student first decides whether to go to college (generally on the basis of cost) and then chooses the preferred college if the decision is affirmative.

The first type of two-stage model relies on the questionable assumption that a person who is unsure about going to college evaluates his range of choices in the same way as a person who is definitely going. The second type of two-stage model relies on the questionable assumption that the choice of going or not going to college is independent of the range of options available. On the other hand, policy simulations of the one-stage model are limited in that, because of the "independence assumption" (see p. 12), removal of a previously considered school option would allocate a proportion of the removed probability to the option of not going. This result is inappropriate for high-ability students because such students would most likely consider other colleges as options before considering the no-college option. As the authors point out, however, the amount allocated to the no-college option will be small because its probability is small in the first place and the new allocation maintains the old odds ratios. Considering all these factors, it appears that the Radner and Miller one-stage procedure provides the most accurate representation.

Measurement of Financial Aid Offers

Financial aid is not treated in the research. The authors argue that its exclusion does not significantly affect the results because financial aid was available to only a small proportion of students in 1966.

Identification of Demand/Supply Relationships

In a discussion of the identification issue based on a review of Campbell and Siegal (1967), Radner and Miller suggest that simultaneous equations bias can come from two sources. First, an aggregate time-series study can involve joint determination of demand and supply by means of the income variable; this is their criticism of the Campbell and Siegal study. Second, to the extent that financial aid is used to attract students with particular characteristics, the cost variable is subject to bias. A third source of bias, using the selectivity cut-off to discriminate among students, is not addressed. The Radner and Miller model avoids the first source of bias because the unit of observation is individual rather than aggregate, and tuition is considered predetermined with respect to family income. Evidently the authors believe that the extent of price discrimination owing to financial aid policy was insignificant in the sample period. Some bias may be associated with the selectivity variable if admissions policies vary across states.

Use of Stratified Estimates

Before the estimates were made, the sample was stratified into four ability groups. There appeared to be significant variation across strata; for example, the coefficient of the cost-income ratio fell in absolute

value as ability increased. Also the ability-selectivity interaction coefficient shifted from negative to positive as ability increased. The first result reflects the greater desire or ability of higher-ability students to finance the increased costs of education compared with lower-ability students. The second result perhaps indicates that low-ability students are unattracted to highly selective institutions and high-ability students are attracted.

KOHN, MANSKI, AND MUNDELL (1974)

Kohn, Manski, and Mundell's study (KMM) in many ways resembles the Radner and Miller study. Both used the 1966 SCOPE data file and the McFadden conditional logit estimation procedure. The two studies also differ in several respects. First, KMM includes only a demand model and therefore appears to be a more complete and unified study. The demand model shows more care in the specification than the corresponding portion of the Radner and Miller study. Second, KMM treats the choice between resident and commuter status, the choice among colleges, and the choice between college and no college separately in a three-stage model. Third, KMM uses individual colleges, rather than representative college types, in the specification of the choice set. In addition, it places more emphasis upon imputation of otherwise unreported data. Finally, its policy simulation is based upon the estimated coefficients and addresses standard questions about the enrollment effects of establishing a new two-year college. This policy analysis stands in marked contrast to that of Radner and Miller, with its loose suggestive connection.

The series of models estimated by KMM covers the full range of quantal choice models in the types of explanatory variables included. In principle,

three types of variables can be involved in a choice analysis problem: (1) chooser attributes, (2) choice attributes, and (3) the interaction of chooser attributes and choice attributes. In education, for example, these types of variables can be illustrated, respectively, by student ability, school selectivity, and the absolute difference between the two. The Radner and Miller model used only the interaction type. The entire KMM model, however, uses all three; the college-choice portion uses both interactions and choice attributes, and the college-going portion uses all three types. The fact that no chooser attribute variables were used in the college-choice model illustrates again the Tversky "elimination-by-aspect" principle, where factors that remain constant across alternatives in comparisons cannot be used in the choice among those alternatives. KMM argues that chooser attributes, entered alone, represent general benefits derived from going to college and thus do not enter into the choice among several college options. The college-going decision, however, depends heavily on individual chooser factors, so they enter the college-going model.

The policy exercise explores the effect of locating a two-year public college near an existing public university. Using the results of the estimated model, the choice of a representative student who lives in the university community is forecast. Three aspects of the student's choice are predicted for various locations of the two-year college. The first aspect is whether the student chooses to live on campus or to commute. The second is the student's utility evaluation of the university and the two-year college at various locations. Finally, the enrollment effects of adding the two-year college at these different locations are calculated from two points of view. From the individual student's point

of view, it is found that the two-year college stimulates new enrollment when the college is located within 20 miles of the student's community. From the public university's point of view, the public college will absorb former university students when it is located up to 70 miles from the community.

Treatment of Higher Education as Consumption Item or Investment

Little formal attention is given to justifying the theoretical framework for the set of explanatory variables included in the three models, apart from describing the three conditional logit models for the residency choice, the college choice, and the college-going choice. Individuals are believed to make rational choices among options by selecting the options yielding the highest utility. The three decisions are regarded as recursive. Given a set of colleges to choose from, the student decides for each college whether he would prefer to live on campus or to commute if he were to enroll in that college. He then ranks all options, given the residency decision, and chooses his preferred college. Finally, he compares the best college option against the best noncollege option and decides whether or not to enroll in the preferred option. To understand what theory is implied in each stage, we must consider the variables included in the empirical specification.

The college residency model is based primarily on current-period considerations, so it is in effect derived from a consumption model. The variables included are distance, income, availability of campus housing, the student's sex, and an indicator variable signifying whether the student prefers to live on campus.

The college choice model depends on four general categories of variables: cost, academic quality, living circumstances, and indicator variables for each of several types of colleges: public or private, two-year or four-year, and the like. The cost variables, which relate primarily to the financial constraint, include tuition, distance, and room and board costs. The academic-quality variables--mean student ability, college revenue per student, and breadth of curriculum--point to both an investment and a consumption concept. A variable measuring the difference between the applicant's ability and the mean ability of the student body is the familiar risk-of-failure variable.

The college-going model includes the utility level calculated from the best college choice and a series of indicators that relate to both parents' educational attainment. The utility variable includes all the factors in the college-choice model, and the parental education variables are an index of the tastes of the family for higher education.

The complete model contains little that could describe an investment decision except for the academic-quality variables. The rest of the specification relates either to the financial constraint or to taste factors. Both the college-choice model and the college-going model are estimated under a three-way stratification of income. The results for the cost variable across income strata are consistent with Hoenack's investment theory.

Selection of the Choice Set

We have already indicated the demanding data requirements of the conditional logit procedure. These requirements necessitated considerable imputation of otherwise unavailable information in the KMM study. Three

elements of the model were imputed in specifying the choice set: family income, the probability of admission to each college in a provisional choice set, and the schools to be included in the final estimation.*

The authors state that they imputed family income by essentially the same procedure used by Radner and Miller; the details are not given.

Since KMM decided to use actual colleges instead of representative types in choice sets, they were faced with large numbers of options for many students. It was necessary to exclude some of these options to obtain a tractable model for estimation. The first exclusion criterion was distance. All schools farther than 200 miles from the student's residence were excluded because only 18 percent of the students in the sample attended schools farther than 200 miles away. All nonresident schools farther than 60 miles away were excluded for a similar reason.

The second exclusion criterion was based on the estimated probability of admission, which depended on the student's class rank, the difference between the student's SAT and the school's median SAT, and the student's sex. The predicting equation was fit to 66 predominantly private four-year colleges with a linear specification. The variables were entered in piecewise linear form to provide for better estimates of the tails of the distribution. A school was included in the choice set if a generated random number exceeded the probability of admission predicted for that school. The predicting equation was tested for bias in predicting admissions to public colleges and was found to be sufficiently accurate.

At this point there were still too many options for tractability, so ten of the options were randomly selected for inclusion in the final

*An unsuccessful attempt was made to estimate the level and composition of financial aid offers. See below.

estimation. One might question whether this arbitrary procedure is any better than the representative type classification use by Radner and Miller. Several alternative subsamples were selected, with no appreciable effect on the final coefficients. We see again that the costliness of the conditional logit procedure forces undesirable specification decisions.

We have mentioned above the recursive nature of the decision problem as modeled by KMM. We also noted that a one-stage model does not impose the independence of decisions a priori. That principle would seem to hold here as well, but the detail of the separate models leads instead to a parameterization problem. In particular, since the lists of explanatory variables differ among the three stages of the model, it is not clear how the conditional logit model would be specified, even if so many parameters could be estimated all at once. The authors allude to this problem before introducing the recursive structure of the model. The recursive structure is obviously limited in imposing the utility calculation of a committed college-goer on an individual who is unsure about going to college.

Another important feature of the KMM choice-set specification is the inclusion of several school-specific attributes and indicator variables in the list of explanatory variables. They considerably improve the measurement of these aspects of the decision process. Furthermore, they allow some choices to be similar along certain dimensions but different along others. This feature would seem to mitigate the rigidity of the "independence assumption" since shifts in intercepts are larger for options that are dissimilar. The logical extension of this approach is the full stratification of the coefficient vector by option type.

Measurement of Financial Aid Offers

An attempt was made to forecast the level and composition of financial aid for each of the college options included in the choice set. Two methods were used. In the first the expected level of aid was predicted directly with a regression equation. The second method estimated the probability of an offer of aid and then estimated the amount of the offer, conditional on receipt. Both methods failed to yield reasonable results, so no financial aid variable was included in the final specification of the college-going or the college-choice models.

Identification of Demand/Supply Relationships

The identification issue is not mentioned. However, to the extent that the admissions equation is correctly specified, the authors may have provided an instrumental estimate. The tuition variables are assumed to be predetermined with respect to the student's decision to enroll.

Use of Stratified Estimates

All estimates of the college-going and college-choice models are stratified on the basis of family income and are fit separately for students living in Illinois and North Carolina. There is no stratification on the basis of ability. The following discussion refers to the Illinois data (the North Carolina data were qualitatively similar).

In the college-choice model the coefficient of the quadratic term for tuition fell for higher levels of income, indicating that higher-income students were less responsive to increases in tuition. Other coefficients in the college-choice models also differed across the income strata. The

coefficients of room and board cost shifted from negative to positive in going from the low-income strata to the high-income strata. This indicates that upper-income groups purchase an amenities component in their housing that acts like a normal good. The coefficient of room and board was consistently lower than the coefficient of tuition, which also reflects the amenities component. The measure of academic quality seemed to influence higher-income groups more than low- or middle-income groups.

In the college-going model, the importance of the father's education variables generally increased as income increased, but the reverse was true for the mother's education variables.

BARNES ET AL. (1975)

The 1975 Barnes study, sponsored by the Inner City Fund, Inc., attempts a comprehensive policy-analytic framework for evaluating the effects of federal grants to college students under the Basic Opportunity Grant (BOG) program. It is an extension of a 1972 Barnes et al. study. Both studies use essentially the same methodology but differ in three important respects.

First, on the basis of the 1972 study results, the authors advocated a new need-based educational grant program given directly to students. The results of the 1975 study were used to evaluate an existing federal program. Second, the earlier study was based entirely on a survey conducted among North Carolina students, whereas the later study extended the model to national scope by using data from the 1971 pilot sample of the NCES National Longitudinal Study (NLS). Finally, the earlier study estimated dichotomous choice models using a linear

probability function, whereas the later study used a dichotomous logit estimator.

The first part of the 1975 study describes the demand model and the results of the estimation. The second part presents extensive simulation results evaluating various policy options under the BOG program.

The demand model is a very simple formulation of the educational demand decision process. The process is seen as a series of five sequential, independent, binary decisions. First, some students decide not to seek more education beyond high school. Among those who do seek more education, some may choose a vocational-technical option and others may choose an "academic" option. Among those who take the academic option and have high measured ability, some may choose a highly selective private college. Those who select the nonselective option must choose between public and private colleges. Finally, those who choose a public college must decide between four-year and two-year schools. There are six terminal points in the decision process: no more education, vocational-technical, selective private, nonselective private, public four-year, and public two-year. The model is estimated by using a dichotomous logit estimator at each decision node. The choice probabilities at each stage are conceived as functions of the prices of options still to be considered, family variables, student ability, and a group of variables indicating the variety of options within commuting distance of the student's home. Alternative policy options are simulated by changing the various prices to reflect different student aid formulas.

The authors caution that the results are preliminary because of the limited nature of the 1971 NLS sample, which they used mainly to demonstrate the feasibility of extending their previous work to national

scope. They plan in future studies to apply their model to the much larger 1972 NLS sample.*

Treatment of Higher Education as Consumption Item or Investment

The theoretical basis is the perception of the educational demand decision as a two-period investment model. The model derived the same results as Hoenack and assumed a limited capital market. Although the theory indicates that both the college-going and college-choice equations should include the expected income differential, neither specification does so. The main principle drawn from the theoretical model is that responses to price changes will differ across income classes. This principle is carried into the specification by the use of income-price interaction terms.

The actual specification of the demand equations includes only student attributes, besides the prices of the various options. The influence of the omitted attributes on the decision thus has to be captured in the price variables, to the extent they are correlated. The bias here may be mitigated by the inclusion of variables to measure the variety of options within commuting distance of the student. Nevertheless, this cannot control for many other likely elements of a student's decision.

The prices are constructed in a complex way to allow definition of the choice set as representative classes of options. Five classes are defined for each student: vocational-technical, public two-year, public four-year, private nonselective, and private or public selective.

*This extension was carried out in Carroll et al. (1977).

Each of these classes contains a list of relevant schools. The aim is to define a price for each class that is a weighted average of the list of schools that could have been included. For nonselective options the student was assumed to consider only schools in his state. Selective schools could be in any state. Several other a priori exclusions were applied to restrict the choice set where race, sex, or academic program would be incompatible with a student's preference. In addition, only the nearest community college was allowed.

For each school included in a class, the joint probability of application and acceptance was calculated from the American Council on Education file of institutional attributes. These probabilities reflect the proportions of students of a given ability range who apply and are accepted at schools of a given selectivity. The selectivity of a school was determined according to a formula based on the school's admission requirements, so the joint probability of application and acceptance could be calculated for any student/school pair. These probabilities were then normalized to sum to one across schools in a class, and the weighted average was calculated. For highly selective schools, a different weighting procedure was used. Only students with high grade-point averages who had pursued a college prep curriculum in high school were considered eligible. For these students, the prices were weighted by the inverse of the distance from the student's home to the campus. The reason was that because of transportation cost, schools that were farther away would enter with less weight into the student's decision. The data file provided some information about alternative offers of financial aid by schools to which the student applied but did not attend. In those cases the option price was based

on the reported information rather than being imputed, as described above. Similarly, the price of the chosen option was always used instead of the imputed price. This gross price was adjusted to reflect room and board or commuter costs reported by the student. Finally, where data permitted, the amount of any financial aid offers was subtracted from the relevant option prices. If the subsidy could be spent anywhere, e.g., social security funds, then all option prices were reduced by the amount of the subsidy. When the subsidy applied to a particular school, only that option price was adjusted. When the subsidy involved a mixture of grant money, work-study, or loans, a formula was used to convert the total offer into a single value designed to represent the present value of the total package.

The authors are to be commended for their diligence and thoroughness in addressing several important issues. Their specification, however, puts excessive weight on the price variable. Embedded in the estimated price coefficients are several theories regarding application, admission, information cost, financial aid, and the present value of its components. These theories are not tested but are arbitrarily imposed on the specification. In addition, the assumption is that a student reacts equally to a change in the constructed prices arising from one or a combination of the theories. Other research has indicated that students show a more elastic response to changes in tuition than to equal changes in cost of room and board. Little faith can be placed in the estimated coefficients because the variance in the "prices" comes from such diverse sources.

It is interesting to compare the Barnes et al. specification with the corresponding parts of the Radner and Miller and KMM studies.

Radner and Miller also used representative classes but calculated unweighted averages and defined their classes in terms of cost and selectivity. KMM simulated admission and used a priori exclusion but let schools enter individually in a probabilistic sense rather than allowing all to enter in a probability-weighted average.

Selection of the Choice Set

In specifying the choice set, the authors adopt a curious position. In the theory section of the 1972 study, the authors impose a particular sequence on the process of selecting among available options. The theory generates a list of jointly defined utility evaluations for each option considered. The theory then implies that the decisionmaker chooses the most highly valued option; no process for making the comparison is implied. The authors assert, however, that the student first compares each option with the no-college option and rejects the latter only when all school options are found to exceed it. Then, a second stage is asserted where the student selects the best among the schooling options. In the empirical model, this concept of stages becomes a dominant feature of the choice set specified. In particular, all schooling options are segregated into classes, and the choice among the classes proceeds in a certain order. No justification is given for the specified order or for the validity of a sequential decision process. One also wonders why the sole basis of choice between the two options is the public versus private attribute. Certainly students are able to decide among several alternatives, jointly comparing more than one attribute for each alternative. The unrealistic nature of this specification can be seen in two examples.

First, assume that a sequential decision process is appropriate but that the true sequence differs from that asserted by the authors. For example, let the second decision node in the true sequence refer to a decision between a short-term educational program and a long-term educational program. Let the short educational program include the vocational-technical schools and the two-year public colleges, and the long program include four-year colleges. In this true sequence, if a student selects the short program branch and rejects the vocational option, he will, with probability one, choose the two-year public college. Suppose, however, that the estimation proceeds with the incorrect model defined by the authors. If the student rejects the vocational option, he will not select the two-year public college with probability one because he must pass through three more decision nodes, the joint probability of which is less than one.

Second, assume that the authors' sequence is not questioned and that the experiment is to analyze the effect of a tuition decrease at four-year public colleges, with all other prices remaining constant. Since the estimated probabilities of all nodes leading to four-year public colleges depend upon the four-year tuition, the probabilities along this path will increase if the tuition is decreased. Suppose now that a student who has decided not to go to college is induced to go to a four-year public school because of the tuition decrease. We must expect that he will enroll in such a school with probability one, but the model does not allow this to occur. In fact, the model allows this student to choose all of the options with some positive probability as a result of the tuition decrease at the four-year college. This outcome violates the axiom of decision theory that nonoptimal choices cannot become optimal

as a result of an improvement in other options.* Sequential decision processes must be truly independent between stages. In the example above, the tuition decrease just could not induce a student to enroll in a vocational technical school. The bias increases with the number of nonindependent stages.

Measurement of Financial Aid Offers

The general criticism of the price variable carries over to the financial aid specification. The authors sought to aggregate all information regarding offers of aid into a single value. Two a priori assumptions were made that could not be tested in the empirical framework. First, the weighting process used to combine the aid components was arbitrary and inappropriate. Separate responses to components of the aid package need to be measured separately because each has important policy consequences. Second, the assumption that a single coefficient can be estimated for financial aid and tuition is likely to represent an inappropriate constraint and produce biased estimates. Again, the specification does not provide for testing the constrained form against the unconstrained form.

Identification of Demand/Supply Relationships

The identification problem is not mentioned with respect to tuition or selectivity. Even if the calculation of admission probability addresses this problem, the effect is again factored into the price coefficient, with all of its suspected biases.

*Luce and Raiffa (1964), p. 288.

Use of Stratified Estimates

The sample in the 1975 study was almost too small to permit much stratification. Furthermore, the sequential decision model reduced the sample size available for each successive binary choice. However, the interaction terms between tuition and higher income were included to test for differences in price-responsiveness across income classes. The coefficients decreased in magnitude and significance for higher parental income.

V. CONCLUSIONS

It is clear from the studies examined above that the policy and specification issues in higher education research are extremely varied and allow no simple assessment of the state of the art. However, several important aspects of the research can be assessed.

Policy objectives are rather vaguely expressed in terms of the long-run benefits to society of encouraging investment in higher education. These benefits must ultimately be measured in terms of increases in lifetime incomes or in social and intellectual skills gained through a college education. Little attempt is made to test the adequacy of the investment model versus the consumption model except in the Bishop study (1975). Two factors complicate the issue. First, as we have pointed out, the monetary returns of obtaining higher education appear likely to decrease over the next two or three decades, so a strong test of the two models may not be possible. Second, the spillover benefits of increased social and intellectual skills are not quantitatively measurable, so their use as a basis of public policy is tenuous at best. As a result, public investment in higher education has become an increasingly expensive and complicated program with little sound justification. Even the goal of increasing social mobility and equality of opportunity is called into question if jobs are not available for new college graduates. Most of the studies reviewed fail to deal with this paradox and proceed as if "supply creates its own demand."

The studies reviewed generally do not handle very well the representation of the choice set pertaining to college options.

Admittedly the relevant empirical techniques are new and unrefined. In any case, because of misspecification of the choice set, empirical studies to date have more than likely produced biased estimates of the true choice probabilities. The determination of how much bias awaits the application of correct procedures.

The effect of offers of financial aid is largely untreated. Some authors assert that, given the paucity of financial aid in the early 1960s, little is lost in excluding it from analysis. What is lost, however, is the ability to explore the potential effects of public policies that use financial aid. We cannot presume, without further evidence, that different types of financial aid packages would have the same effect as an equivalent reduction in tuition. The availability of new data sets with detailed information on financial aid offers will enable this defect to be corrected in future research.

Most studies circumvent the identification problem by concentrating on cross-sectional data sources. However, in the face of projected decreases in enrollment, the supply side of the educational market needs to be analyzed in more detail. The question of simultaniety must be analyzed not only with respect to tuition and financial aid but also with respect to admission policies.

Finally, much evidence suggests that response rates vary across ability and income classes. Future research needs to set flexible specifications to allow for the determination of different responses across relevant categories of students. One such topic that has been slighted is the differential response between men and women.

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